

Application  
for  
United States Letters Patent

To all whom it may concern:

Be it known that we,

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have invented certain new and useful improvements in

METHOD AND APPARATUS FOR DEFLASHING OF INTEGRATED CIRCUIT PACKAGES

of which the following is a full, clear and exact description.

### Method and apparatus for deflashing of integrated circuit packages.

5 This invention relates to a method and apparatus for laser deflashing of integrated circuit (IC) packages. In particular, it relates to a method and apparatus for removing flash from heat sinks as well as leads and bars in IC packages without damage.

A plastic-encapsulated microcircuit consists of an IC chip physically attached to a leadframe, electrically interconnected to input-output leads mid moulded in a plastic that is in direct contact with the chip, leadframe, and interconnects. With major  
10 advantages in cost, size, weight, performance, and availability, plastic packages have attracted 97% of the market share of worldwide microcircuit sales.

During the moulding process, it is known that moulding compound can flow through the mould parting line and onto the leads of the device. In its thinnest form, this material is known as resin bleed or thin flash. A thicker bleed of material is known as flash. If  
15 this material is left on the leads it will cause problems in the downstream operations of lead trimming, forming, and solder dipping and/or plating. In some cases, plastic packages are designed with an integral heat spreader exposed to air to meet high thermal and electrical performance demands. The die is attached directly to the heat spreader to minimize the thermal resistance. During the moulding process, moulding  
20 compound usually leaks out and forms flash on heat sink surfaces. This will greatly limit heat sink function and even cause damage of the plastic packages. Therefore, deflashing of IC packages is one of critical processes in the manufacturing.

Mechanical and chemical deflashing are conventional deflashing techniques in IC packaging lines. For removing resin bleed or thin flash, it is excellent to use chemical  
25 deflashing technique. Plastic packages are immersed in a chemical tank for a specified time and checked for the degree of deflashing. Effectively deflashed components are rinsed and air-dried. However, it has distinct drawbacks. First, chemical solution used for deflashing can potentially hurt component performance. Second, there is the

significant cost of handling and disposing toxic materials during and after deflashing. Mechanical deflashing techniques such as suction gun, pressure gun, wet blast and impeller wheel are usually used to remove flash on round leads, heat sinks and lead frames, and flash between tie bars and leads. However, it also has distinct drawbacks as shown in R. F. Zecber "Deflashing encapsulated electronic components"; *Plastics Engineering*, June (1985), pp. 35-38. For example, some dust is needed to clean up.

Laser deflashing as a new deflashing technique was disclosed in US patents Nos. 5099101 and 5961860, and Singapore patent WO 00/37209. In above patents, YAG laser or excimer laser is used to remove flash. Since heat sinks as well as leads and bars are made of copper or copper substrate with metal coating layers, YAG laser or excimer laser easily induces damage of heat sinks as well as leads and bars in air at high laser fluence. Our new findings indicate that as flash especially thick flash has been removed by YAG or excimer laser ablation, the laser also induces damage such as oxidation of heat sinks as well as leads and bars. In fact, only thin flash can be removed by YAG or excimer laser deflashing at low laser fluence and pulse number without damage such as oxidation of heat sinks as well as leads and bars. Therefore, how to remove flash without damage is key issue for laser deflashing application in industry

In accordance with a first aspect of the present invention there is provided a method of deflashing IC packages. The method comprises the steps of directing a first laser beam in the infra-red frequency range onto flash area for removing top layer of flash; and subsequently directing a second pulsed laser beam onto the flash area at low laser fluence and pulse number for removing the thin layer of flash remained after application of the first laser beam.

Since heat sinks as well as leads and bars are high reflective materials to infra-red radiation, the first laser irradiation only induces low temperature rise of the heat sinks, leads and bars. In addition, the thin layer of flash remained after the first laser deflashing plays an important part in avoiding damage such as oxidation. Therefore, the damage can be effectively avoided during the first laser deflashing. when infra-red laser irradiates the flash area. The first laser can effectively remove top layer of flash especially thick flash. However, a thin layer of flash remains on heat sinks as well as

- leads and bars after the first laser deflashing. That means that the first laser deflashing on its own cannot meet industrial demands. To complete effective deflashing, the second laser is applied deflashing at low laser fluence and pulse number can effectively remove the thin flash remained after the first laser deflashing without damage in accordance with this invention.

The first laser may, for example, be a CO<sub>2</sub> laser. It may applied in pulses, each with a typical duration in excess of 1  $\mu$ s. Alternatively, it may be applied in a continuous wave (CW) mode.

- The second laser may operate over a wide spectral range, for example, from infra-red to ultra-violet. It may suitably be a YAG laser. The second laser is, most preferably, applied in short-duration pulses. It has been found that a pulse length of less than 100ns is to be preferred to produce effective deflashing, without causing a significant and detrimental temperature rise in sensitive components, such as leads and bars, of the IC at low laser fluence and pulse number.

- In accordance with a second aspect of the present invention, there is provided an apparatus for deflashing IC packages comprising: a conveyor system for carrying IC packages to appropriate position; a mask placed on IC packages for exposing flash area to laser beams; first and second lasers for generating laser beams; and a scanning system for each laser; wherein the belt conveyor is movable relative to each laser beam, the two galvanometers being used to scan respective laser beams in turn on a flash area of the IC packages.

With the present invention, the damage of heat sinks as well as leads and bars can be effectively avoided; the flash on heat sinks as well as leads and bars can be effectively removed by laser irradiation.

- Apparatus embodying the invention may further comprise an exhauster for removing flash debris.

The first laser may be a CO<sub>2</sub> laser. Moreover, the first laser may be a pulsed laser or a continuous wave laser.

The second laser is typically a YAG laser. The second laser may have a wavelength of 1064 nm or 532 nm.

In typical embodiments, the second laser has predetermined pulse-duration. For example, the predetermined pulse duration is between 1 fs and 1000 ns; e.g. 7 ns.

- 5 Embodiments of the invention will now be described in detail, by way of example, and with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram showing the apparatus according to one embodiment of the present invention;

- 10 Figure 2a is a microscope photo showing a sample of heat sink in an IC package deflashed by a prior deflashing method using YAG laser irradiation at  $300 \text{ mJ/cm}^2$ ;

Figure 2b is a microscope photo showing another part of the same sample deflashed by a prior deflashing method using YAG laser irradiation at  $300 \text{ mJ/cm}^2$ ;

Figure 3a is a microscope photo showing a sample of heat sink in an IC package deflashed by a prior deflashing method using YAG laser irradiation at  $720 \text{ mJ/cm}^2$ ;

- 15 Figure 3b is an X-ray photoelectron spectroscopy (XPS) Cu2p spectrum of Fig. 3a;

Figure 4a is a microscope photo showing a sample of heat sink in an IC package deflashed by the method of the present invention using  $\text{CO}_2$  and YAG laser deflashing.

Figure 4b is an X-ray photoelectron spectroscopy (XPS) Cu2p spectrum of Fig. 4a;

- 20 Figure 5a is a microscope photo showing a sample of heat sink in an IC package deflashed by the method of the present invention using  $\text{CO}_2$  laser deflashing;

Figure 5b is a microscope photo showing the same sample of Fig 5a deflashed by the method of the present invention using YAG laser deflashing; and

Figure 5c is an X-ray photoelectron spectroscopy (XPS) Cu2p spectrum of Fig. 5b.

- 25 Refer now to Figure 1. The apparatus for deflashing IC packages according to one embodiment of the present invention comprises a first laser 10. The first laser is a  $\text{CO}_2$

laser that generates a laser beam 20 in the infra-red range, in this embodiment, with a wavelength of approximately 10.6  $\mu\text{m}$ .

5 A galvanometer 30 for first laser 10 is used to scan the  $\text{CO}_2$  laser beam 20 onto an IC package 40 along a predetermined path. A mask 50 is used to expose only the flash area on the IC package 40 to laser beam 20. The IC package 40 with the mask 50 is placed on belt conveyor subsystem 60. After the first laser deflashing, the IC package 40 is carried from position A to position B by the belt conveyor subsystem 60 for following a second laser deflashing operation. Meanwhile, another IC package can be carried to position A for its first laser deflashing.

10 A second laser 70 is in this embodiment, a YAG laser for generating a YAG laser beam 80 having a wavelength of 532 nm or 1064nm. A galvanometer 90 for the second laser 70 is used to scan the YAG laser beam 80 onto the IC package 40 as it passes along its predetermined path.

15 An exhauster 100 is used to take away flash debris removed by  $\text{CO}_2$  and YAG laser deflashing. A gas blower 110 is also provided to reduce heating of the IC packages by blowing gas, such as compressed air or  $\text{N}_2$  gas through a nozzle onto the packages.

As shown in Figures 2a and 2b, one sample of heat sink was deflashed according to a prior art laser deflashing method. A YAG laser was used with a wavelength of 532 nm. The pulse duration is 7 ns. The laser fluence was 300  $\text{mJ}/\text{cm}^2$  and pulse number is 4.  
20 At an irradiated area 210, fresh heat sink surface can be seen. A thin layer of flash exists at non-irradiated area 220 as shown in Figure 2a. This indicates that thin flash can be easily removed by YAG laser deflashing. However, a thick layer of flash at irradiated area 230 in Figure 2b cannot be removed by YAG laser deflashing at 300  $\text{mJ}/\text{cm}^2$  and 4 pulses.

25 Figure 3a is a microscope photo showing an sample of heat sink in an IC package deflashed by a prior art deflashing method using YAG laser irradiation at 720  $\text{mJ}/\text{cm}^2$  and 10 pulses. Although thick flash in area 250 has been removed, damage to the heat sink surface has taken place. Figure 3b is an X-ray photoelectron spectroscopy (XPS) Cu2p spectrum of the same sample of Figures 3a and 3b after YAG laser deflashing at

a wavelength of 532 nm, a laser fluence of  $720 \text{ mJ/cm}^2$  and a pulse number of 10. Four peaks are observed in the XPS Cu2p spectrum as shown in Figure 3b. This indicates that damage such as oxidation of heat sink has taken place. Comparing Figures 2 and 3, we can conclude that a YAG laser can only remove thin flash without damage at low laser fluence and pulse number. A YAG laser cannot remove thick flash without damage. The same effect was observed after deflashing using an excimer laser.

Figure 4a is a microscope photo showing a sample of heat sink in an IC package deflashed by the method of the present invention in apparatus described with reference to Figure 1. A first laser deflashing operation was carried out using the first laser 10 at a power of 10 W, pulse duration of 20  $\mu\text{s}$ , a repetition rate of 2000 Hz and a scan speed of 5 mm/s. Subsequently, a second deflashing operation was performed using a the YAG laser 70 at a wavelength of 532 nm, a laser fluence of  $300 \text{ mJ/cm}^2$  and a pulse number of 4. As shown in Figure 4a, flash in area 260 has been removed by the method of the present invention without damage. Figure 4b is an XPS Cu2p spectrum of the same sample of Figure 4a. Comparing the XPS Cu2p spectrum of the heat sink with the standard XPS spectra of Cu2p observed in copper, cuprous oxide and cupric oxide, it was found that the XPS Cu2p spectrum of the heat sink is the same as the standard XPS Cu2p spectrum of copper. Therefore, no damage such as oxidation of the heat sink surface has taken place by the deflashing operation embodying the invention.

Figure 5a is a microscope photo showing a sample at heat sink in an IC package deflashed by the method embodying the present invention using  $\text{CO}_2$  laser deflashing. The heat sink is made of copper. The pulse duration is 20  $\mu\text{s}$  and the repetition rate is 2000 Hz. The power is 10 W and scan speed is 5 mm/s. It is found that top layer of flash in area 270 has been removed and a thin layer of flash still exists on the heat sink surface. Figure 5b is a microscope photo showing the same sample of Figure 5a deflashed by the method of the present invention using YAG laser deflashing. The laser fluence is  $400 \text{ mJ/cm}^2$  and pulse number is 2. The laser wavelength is 1064nm and pulse duration is 7ns. It was observed that the thin flash remained on the heat sink after  $\text{CO}_2$  laser deflashing has been removed without damage as shown in area 280 of Figure 5b. Figure 5c is an XPS Cu2p spectrum of the same sample of Figure 5b. Comparing the XPS Cu2p spectrum of the heat sink surface with standard XPS spectra of Cu2p

observed in copper, cuprous oxide and cupric oxide, it was found that XPS Cu2p spectrum of the heat sink surface is the same with standard XPS Cu2p spectrum of copper. Therefore, no damage such as on oxidation of the heat sink surface has taken place. Therefore, the present invention can be used to effectively remove thin or thick flash without damage.

The present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The presently disclosed embodiments are therefore, to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims and all changes which come within the meaning and range of equivalency of the claims are therefore to be embraced therein.